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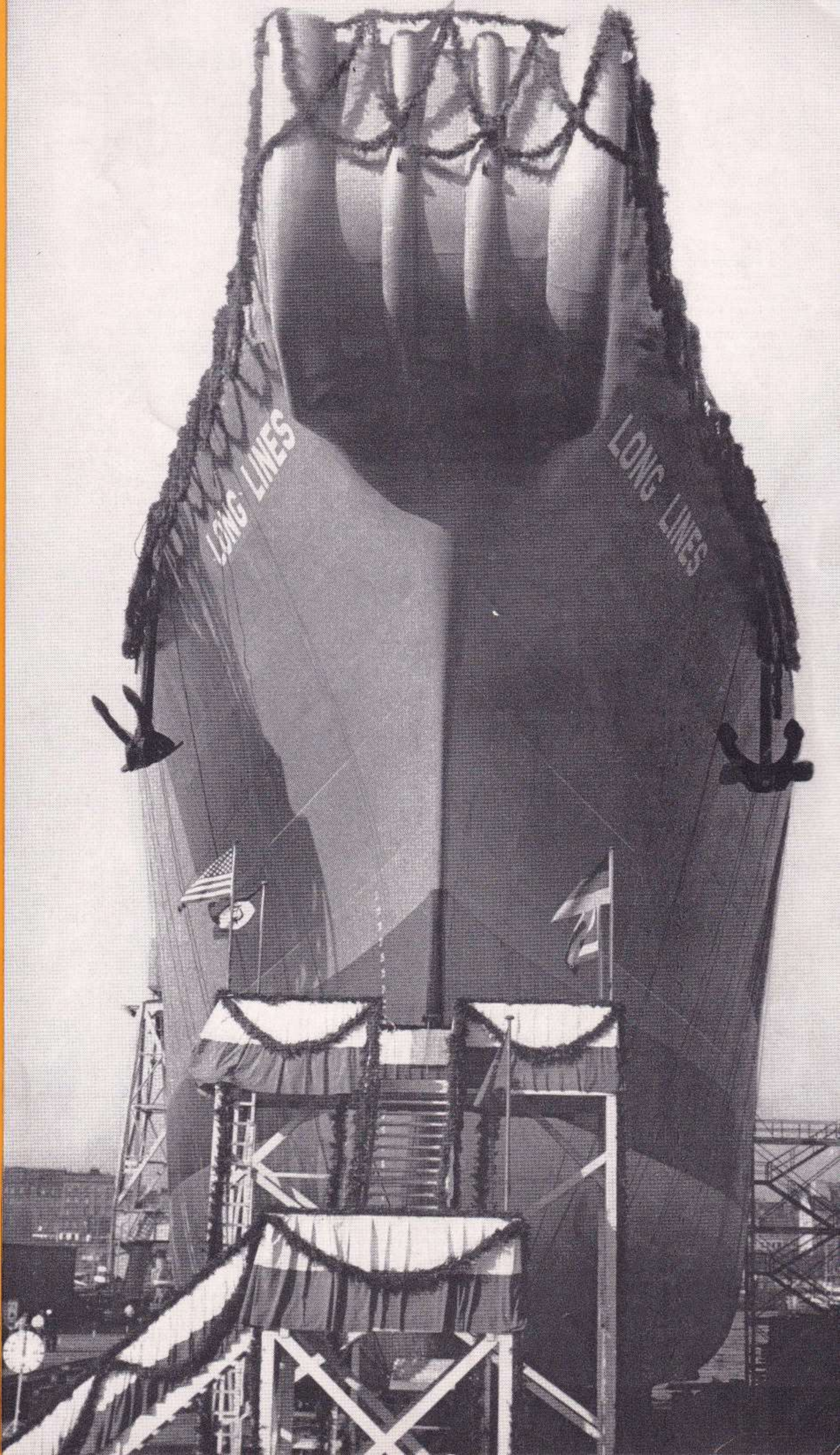
The Producer Goods EXPORTER



The Producer Goods EXPORTER

THE PRODUCER GOODS EXPORTER is published quarterly by the Producer Goods Export Department of International General Electric Company, a Division of General Electric Company (USA). Its purpose is to provide readers with news and useful information on General Electric apparatus equipment and the activities of the Producer Goods Export Department.

THE EXPORTER is distributed free of charge to IGE customers interested in more efficient use of electric power for greater productivity, to IGE distributors, and to General Electric affiliated companies around the world.

News contributions, comments, and change-of-address notices should be addressed to the editor, Room 700, 159 Madison Avenue, New York 16, New York.

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ON THE COVER

WORLD'S LARGEST cable-laying ship, the 16,020-ton *Long Lines*, was launched this fall at Schlieker Werft in Hamburg, West Germany, for the American Telephone & Telegraph Co. IGE supplied the propulsion and auxiliary power equipment.

Looking Back

At his annual year-end press conference, Ralph J. Cordiner, General Electric's Chairman of the Board, reported that 1961 will be the biggest year in the history of International General Electric Company in orders received for exports.

"In overseas markets as well as the domestic field," said Mr. Cordiner, "General Electric is placing great emphasis on the 'systems approach,' bringing to bear the Company's broad capabilities in supplying equipment, engineering, and financing for major turnkey projects." Mr. Cordiner cited a recent $28 million IGE contract for gas turbines and related equipment for an oil project in the Middle East. "This order," said Mr. Cordiner, "is not only important in itself, but it could be a major breakthrough for several of our product lines in the international petroleum field."

In discussing General Electric's research and development activities, Mr. Cordiner cited a recent study by the U. S. Senate Judiciary Committee. According to this study, reported Mr. Cordiner, "it appears that the General Electric Company in the past 10 years has conducted the most extensive research and development activities of any company in the United States, and presumably in the world."

"In the years from 1950 through 1959," Mr. Cordiner continued, "General Electric spent $1,370,000,000 of Company funds for research and development activities, and in that same period the Company also performed $1,500,000,000 worth of research and development work for the U. S. Government . . . A high level has been maintained in 1961 and will be continued in 1962," said Mr. Cordiner.

Looking Ahead

The November issue of the General Electric *Monogram* reported that General Electric has issued a formal policy on product quality. According to the *Monogram*, the policy document points out that "over the years General Electric has continued to earn an outstanding reputation for offering products of good quality." But, the policy document continues, "greater attention to product quality is needed, however, if the Company's standing with customers and the public is to be enhanced."

The policy objective is explicitly stated: "that the quality of each General Electric product will be such as to meet reasonable expectations of customers for that product in relation to price paid and nature of competitive offerings, and that General Electric products rank *first* in earned reputation for giving this satisfaction."

PUBLICATIONS AVAILABLE FROM INTERNATIONAL GENERAL ELECTRIC

NULL BALANCE RECORDERS AND RECORDING CONTROLLERS—GEA-6887A, 12 pages, describes General Electric's complete line of single and multi-pen null balance recorders and recorder-controllers. Also discussed are multipoint recorders and multi-purpose indicators. Descriptions of typical measurements performed by the recorders and controllers are outlined in a special section. The illustrated bulletin contains information on features, dimensions, specifications, optional accessories and applications.

PREFERRED DESIGN POWER TRANSFORMERS—GEA 6604B, 12 pages, illustrated. Gives scopes, dimensions, product features, benefits and basic concept of General Electric Preferred Design power transformers rated up to 230 kv, 400,000 kva.

Included are details on new low-height design, reduced floor space requirements, new cooling arrangements and other improvements for transformers rated up to 25,000 kva. The improvements were suggested by 32 electric utilities and consulting engineers interviewed last year.

HIGH VOLTAGE POWER TRANSFORMERS—GEA 7196, 12 pages, illustrated, describes General Electric extra-high-voltage power transformers operating at 345, 500 and 700 kv.

Publication explains trends in EHV units and discusses their economics. Also outlined are benefits of autotransformers and bushing-mounted load-tap changers for EHV transformers which tie new super-voltage lines to existing transmission systems.

Copies of these publications are available from: Advertising and Sales Promotion Section, International General Electric Company, 159 Madison Avenue, New York 16, N. Y.

Automation of Marine Power Plants

A General Electric marine expert looks at changes in engine rooms as new concepts gain greater acceptance.

By John F. Nace

John F. Nace is manager of marine systems sales and engineering, Marine and Defense Facilities Sales Operation, General Electric Company, Schenectady, N. Y.

The term "ship automation" is extremely broad and means many things to many people. To some, it means a fully automatic ship capable of sailing from pilot station to pilot station with no crew aboard. It raises thoughts of automatic navigation for some, automatic cargo handling or automatic power plants for others. This article pertains to the automation of marine power plants, specifically steam turbine power plants since they are universally accepted in the marine business.

A concept of an automated steam turbine marine power plant is presented for consideration and discussion to give marine engineers and shipowners perspective which will permit them to identify and anticipate the problems or changes and provide for them on new designs.

Many words are being used today such as automated, mechanization, or integrated. Definitions have been developed for each of these terms, and each year the definition changes slightly in order to adjust for the changes that are gradually taking place in the equipment and in the industries using it. In this article, only one term, i.e., "automation" is used, and it is used in a broad sense. Automation in this broad sense refers to a method or system of getting the work done *more economically* and with *improved reliability*.

Basic Concept

The broad basic concept is a propulsion power plant that normally requires one man on watch in the engine room and, in effect, part time of a man on the bridge. The man on the bridge provides only one function, i.e., the adjustment of the propeller revolutions. The man stationed in the engine room provides a number of functions; principally, *decision*. He also observes, actuates components and supervises subloop controls.

The man on watch in the engine room is assisted in carrying out his functions "by control function equipment" which is centralized at a station in a group of consoles and instrument panels that are fully equipped with the required displays, alarms, switches and mimic diagrams.

The functional requirements imposed upon the equipment and men are the foundation upon which a concept such as this is developed and, therefore, they must be established before the specific features of the concept can be presented.

The automated power plant control system performs the following functions:

1. Sensing (pressure, temperature, flow, RPM)
2. Measuring
3. Information processing, including data logging and display
4. Monitoring, including alarm
5. Controlling (safety protection; sustain normal "on-line" operation for the four normal modes of operation; changeover from one normal mode to another).

The automated power plant control system recognizes and sustains four normal modes of operation—two with propulsion (steady state at sea, maneuvering), and two with no propulsion (idle, cargo working).

The two other operating conditions—start up/shut down and emergency—are recognized; however, these conditions are not normal and require additional manual regulation and action.

In addition to the five functions listed above, there are two others that must be performed with respect to machinery on board a ship. These are maintenance and repair. The automatic control system cannot accomplish these functions, because they are manual work which must be done by men with the aid of tools. Maintenance is manual work required to maintain the performance and reliability of the power plant, and it is done at regularly scheduled intervals; for example, daily, each voyage or perhaps annually. Repair is manual work required to restore equipment that has suffered accidental damage.

The automated power plant concept is developed by treating each function to determine the best combination of men and equipment for its accomplishment. The primary objective is to accomplish the functions more economically and with improved reliability. The automated power plant incorporates some techniques and equipment that are new to the marine power plant. It requires integrating of the instrumentation, upgrading of the subloop controls and extremely reliable low maintenance components. One of the purposes of this article is to expose these innovations so that they can be considered and discussed.

Instrumentation

Sensing, measuring, information display and monitoring are usually considered as instrumentation, and they are. However, in this concept they are not treated separately as instrumentation; instead they are treated as a part of the "control function," because the type of components and systems best suited for the accomplishment of these functions depends upon the type of equipment used to perform the fifth function, i.e., controlling. Pressures and temperatures are converted to electric signal voltages that are lineally proportional to the quantity being sensed. Flows and rpm produce electric signal pulses at a rate proportional to the flow. All quantities, therefore, are converted to electric signals for use in the "control system."

Many of these signals are merely scanned for monitoring and alarm. Others are visualized and displayed at the control station. A few are logged on paper, some are used in the sequence control during change from one mode of operation to another. This brief consideration of the use of information that is sensed emphasizes the need for coordination of the detailed requirements and characteristics of the instruments and the control equipment. The use of this type of instrumentation is an innovation because it has been used only to a limited extent in marine power plants, although it has been used extensively in process industries and shoreside power plants.

Data Logging

Information processing, including data logging and information display and monitoring including audio and visual alarm, are performed by special equipment provided at the centralized control station. These functions are all done "automatically" to assist the man on watch. The words *information processing including data logging* are used deliberately to emphasize that the equipment does more than merely log data. This equipment is built up of solid state circuitry and can be thought of as a digital computer in the sense that it can do more with the information that it receives than simply log it; however, it is not a digital computer as the word is commonly used today. The following quantities are typed out on the log sheet:

Temperatures

- Boiler superheater outlets*
- Steam to main turbine*
- External desuperheat outlet*
- Boiler uptakes*
- Turbo-generator supply
- D. C. heater
- Fourth-stage heater outlet (boiler inlet)
- Sea water inlet

Pressures

- Combined superheat outlets*
- F.O. pressure to burners*
- Turbo-generator supply*
- Main condenser vacuum*
- L.P. steam generator shell*
- Feed pump discharge
- Forced draft fan discharge

Cumulative Flow

- Boiler steam flow*
- Condensate pump
- Atmosphere drain pump
- F.O. meter
- Evaporating plant output
- Flows to T.G. set and feed pump

Other

- Time
- KW hour meter
- 0_2 recorders
- Turbine valve position
- Shaft horsepower
- Propeller rpm
- Forced draft fan speed

The items marked with an asterisk are also displayed at the control station. All of the items listed and many others are scanned constantly by the monitor, and an alarm is given automatically if the quantity has deviated from its pre-set band.

The data logger prints out all of the items on the log sheets automatically at intervals of one hour unless the man on watch sets it up to 15 minutes. The man on watch can demand a complete set of data at any time by simply pushing the button.

The scanner selects one input point at a time. This signal is converted to DC, which is converted from analog to digital form, then stored momentarily in a memory bank. From here it is fed at the proper time to the typewriter, which prints it on the paper. This equipment is arranged so that if the monitor picks up an off-normal item and sounds the alarm, the data logger will print the time of the alarm along with the item and its value, thereby providing a record for future examination.

This equipment does a limited amount of calculation; for example, it calculates the observed specific fuel consumption. This automatic monitoring, alarm, information processing and data logging makes it unnecessary for the man on watch to be constantly examining all of the information on display and permits him to move about in the engine room so that he can supervise the operation of the equipment and perform a certain amount of manual work.

A complete intercommunication system is provided between the bridge and the control station so that the two men are in complete communication with each other although they are physically in different parts of the ship. Closed-circuit TV cameras are installed in the engine room and a viewer is located on the bridge.

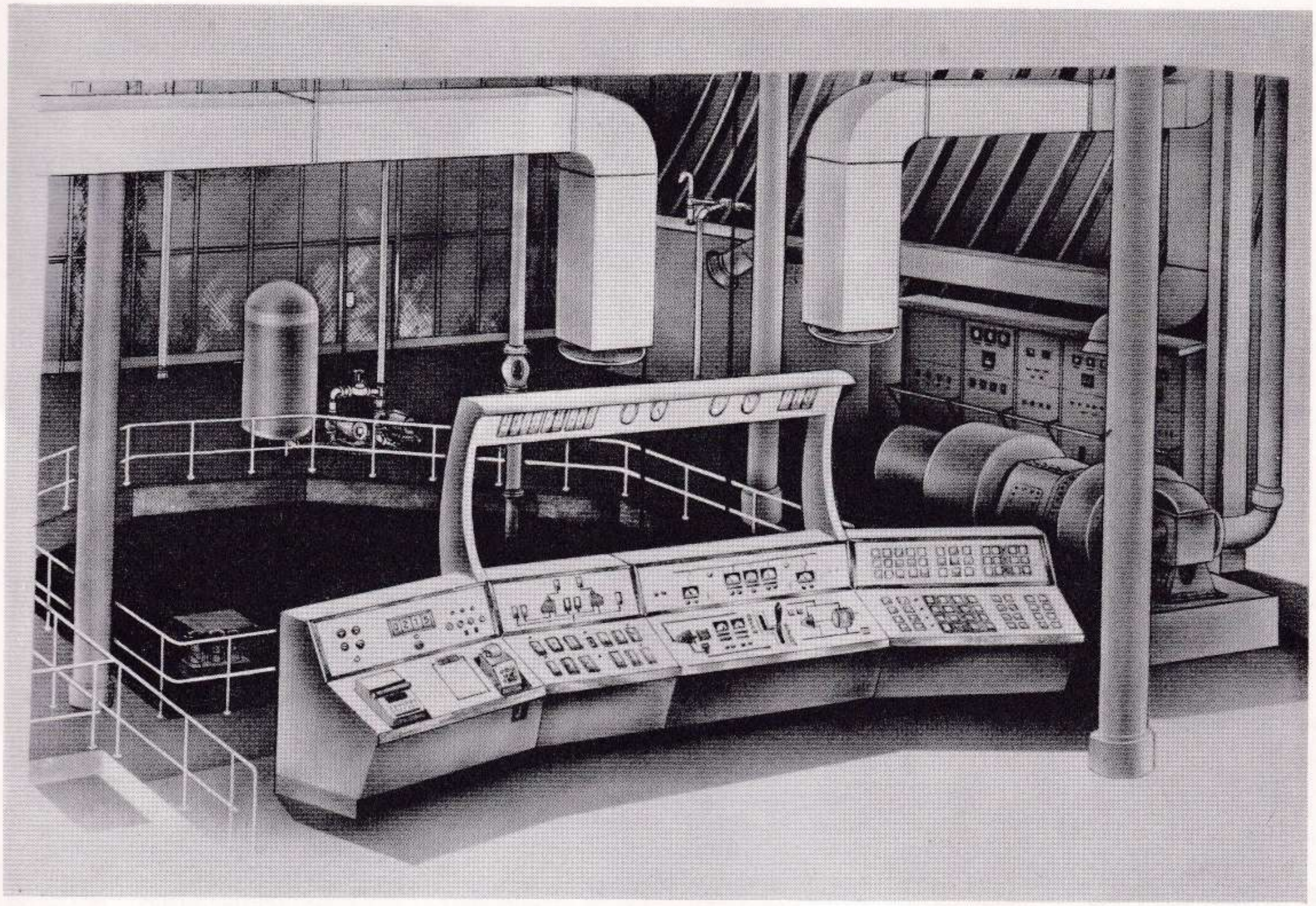
Control

The control function can be considered more readily if it is segregated into three sub-functions; i.e., safety protection, sustaining normal on-line operation, and changeover from one mode to another.

The *safety* control is built into each component and system as required, and in accordance with the usual practice and regulations; for example, the overspeed protection on the propulsion turbines is provided by a conventional pump governor system that has been used for years. The boilers are equipped with safety valves in accordance with existing regulations. Motors and generators are protected from overload in accordance with standard practices.

Normal operation in any of the four normal modes is sustained by means of analog subloop controls which are similar, and in many cases the same as presently being installed in new ships. The following systems are controlled in this manner and in normal operation require only supervision by the man on watch:

- Steam Pressure—Superheater Outlet
- Steam Temperature—Superheater Outlet
- Fuel Pressure
- Fuel Temperature & Viscosity
- Air/Fuel Ratio
- Water Level in the Boiler Drum
- Water Level in Surge Tank
- Boiler Feedwater Temperature
- Pressure in the Direct Contact Feed Heaters



DATA LOGGER and Control Console for advanced steam turbine engine room by George G. Sharp Co.

Sealing Steam on the Turbine Shaft Glands
Forced Draft Fan Speed
Lube Oil Pressure
Lube Oil Temperature
Electric Power Generation (Voltage and Frequency)
Fresh Water Production

The man on watch has to make decisions and initiate action only to accommodate abnormal conditions which he observes or which are brought to his attention by the monitoring and data logging system.

There are two basic modes of operation with propulsion power required—"steady state at sea" and "maneuvering." The man on the bridge decides upon the proper mode at any particular time and orders the man on watch in the engine room to set-up for the mode that he has selected. A number of definite and specific things have to be done in order to change the set-up from one mode to another. The man on watch is relieved of the majority of the work by sequence control, which automatically and in proper sequence changes the power plant set-up from one mode to the other. The man simply initiates the sequence control action by moving the set-up lever to the mode which has been ordered by the man on the bridge. Not all of the work required in changing the set-up is done automatically by the sequence control; for example, changing the fuel oil burner from mechanical to steam atomizing is done manually. The amount of manual effort and time required by the few items that are changed over manually is reduced to a minimum by proper design and arrangement of the equipment.

This concept can be illustrated by consideration of a typical series of events. For example, a ship has been at sea for a few days under the steady state mode. As it approaches port—perhaps an hour out—the man on the bridge informs the man in the engine room that they are approaching port and orders a change to the maneuvering mode of operation. The man in the engine room moves the set-up lever from steady state at sea to maneuvering, and this initiates the sequence control which automatically

1. changes all sea suctions from low to high
2. secures the evaporator
3. starts the standby ship's service generator. The generator is brought up to speed but not connected in parallel on the bus.

The man in the engine room proceeds to change the fuel oil burners from mechanical to steam assist.

After the ship has been brought up to the dock and the bridge has "finished with engines," the man in the engine room moves the set-up lever to either the *idle* or the *cargo working* mode depending upon the situation. The automatic sequence control merely assists the man to change the set-up from one mode to another and the amount of this type of control is a minimum consistent with the capability of the man to perform some of the work.

The control station is equipped with start/stop switches and indicating lights for every component that is arranged for remote operation, such as standby condensate, boiler feed and lube oil pumps, electric generators, main sea valves, etc.

Abnormal and infrequent operating conditions such as cold start up or complete shut down and emergencies are accommodated by providing additional manpower in the engine room during that period of time.

The features that represent the greatest innovation from the point of view of automation and, therefore, deserving of more emphasis and consideration are these:

Fuel Oil Burners—Wide range burners are used which permit operation of the boilers over a range of at least 10-1 without necessity for cutting burners in and out or changing tip sizes. The wide range is obtained by providing atomizing steam to the burners to assist the atomization of the fuel at the low firing rates. The steam atomizing burners are required only during the maneuvering mode of operation. When the plant is operating "steady state at sea," the man on watch removes the steam atomizing burners and replaces them with straight mechanical atomizing units in order to conserve the atomizing steam. The oil burners are arranged so that this operation can be performed with a minimum of manual effort and in a minimum of time.

Flame Detectors — Flame detectors are provided for each burner to alarm the man on watch if a burner loses flame.

Fuel Viscosity Control—A system is provided to automatically maintain the proper viscosity of the fuel oil going to the burners.

Soot Blowers—Automatic sequential operation of all soot blowers.

Combustion Control—Direct flow measurement of fuel oil and air is used to improve wide range operation.

Forced Draft Fan—Speed automatically changed in steps to optimize the control of combustion air.

Maintenance & Repair

There is maintenance and repair work that must be accomplished aboard a ship and, consequently, men must be carried to do it. Some of this work is required in the engine room; however, a considerable amount of it is required outside the engine room on such items as whistle, deck machinery, lights, cargo reefer equipment, and galley equipment.

Historically, this work has always been done by the engine department and, consequently, has been and is considered machinery maintenance and repair, although it is not related to the power plant. These maintenance men are available, and a part of their time is used on a daily basis to accomplish the relatively small amount of maintenance work required by the power plant and its equipment in order to maintain its performance and reliability. The following tasks are done once a day by the maintenance men:

Boiler Water (test chemistry, add required chemical, blow down as required).

Fuel Oil (transfer from tank to tank, clean strainers, clean atomizers).

Lube Oil (clean strainers, clean purifier).

The U. S. Coast Guard and the American Bureau of Shipping require periodic inspection of specific pieces of equipment. Some of this work has to be done when the ship is in port; however, a considerable amount of it can be accomplished while the ship is underway at sea. The maintenance men carried on board will take care of as much of this routine work as practicable.

The practicability of reducing the number of men carried on board a ship is determined more by the amount of maintenance and repair work required than it is by the automation of the "control function." If the equipment does not have high reliability and availability and requires frequent maintenance work, it is not practical to remove much if any of the maintenance and repair staff normally carried on board.

It is possible to design, manufacture and install mechanical and electrical systems which have a very high reliability and availability. This is a fact and has been proven in many specific cases; for example, the household refrigerator contains a complete and complex refrigeration plant. Experience proves that these plants will run with 100 percent availability and reliability for periods of 15 to 20 years. Many hydropower stations operate unattended and without maintenance for months at a time. Industries dealing with radioactive materials find maintenance and repair costs so high that they make certain that their components and systems have 100 percent availability and reliability. This high degree of reliability is obtained by giving adequate attention to the design and quality of each component. "A chain is no stronger than its weakest link." The thought behind this old saying is very appropriate to the subject of reliability. There are some vital components whose failure can cause the shutdown of the complete process or power plant; therefore, these components must have high reliability.

Some shoreside fossil-fuel burning power plants have demonstrated such high reliability that they remain on-the-line for 18 months at a stretch. Experience with these types of power systems proves that this high reliability, particularly with the accessories such as fuel pumps, is only obtained if each vital component, large or small, is selected on the basis of *quality* as demonstrated by performance in service and *value* from qualified suppliers. Experience also proves that this high degree of reliability cannot be obtained or assured if all of the vital components are merely auctioned off to the lowest price.

Conclusions

- An automated power plant developed in accordance with the basic concept expressed in the paper is practicable.
- The most significant technical innovations related to automation of the control function in the power plant are:
    1. The centralized control station
    2. Information processing and data logging equipment
    3. Electric instrumentation system
    4. Wide range fuel oil burners
    5. Flame detectors
    6. Bridge control of propeller rpm
    7. Intercommunication between the bridge and the engine room.
- The reliability and quality of the components and systems directly affects the amount of maintenance and repair work required which, in turn, affects the number of men that must be carried on board just as much or more than the automation of the control function.
- To be successful and reliable, an automated power plant must be a completely integrated and coordinated power system from its conception, through its design and installation and not simply a consolidation of components.

The Automated Hot Strip Mill

By W. E. Miller

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The continuous hot strip mill is probably the most important entity in the production of high quality strip, sheet and plate products. Such mills represent extremely large capital investments. The operation of these mills is very complex, since a large number of factors and adjustments must be considered and carefully controlled if the optimum production rate and product quality are to be achieved.

Considering all these factors, there is probably no single process in the steel industry better suited, economically, for the application of advanced automation techniques and control.

A new automated hot strip mill will include a number of basic features: main drive speed regulators, automatic gage regulator, roll opening positioning regulators, automatic looper operation, automatic mill set up, data logging and processing, and production scheduling.

Automatic Gage Control

System design and successful performance result from several factors. These include:

Intimate and detailed understanding of rolling mill process.

Comprehensive analysis of process system including plastic flow in the roll bite, deflections in the mill structure and the overall controlling electric system.

Comprehensive process tests to check system operating range, accuracy and transient response.

Several significant factors of process behavior, rolling practice and gage control will be examined to better understand the performance capabilities and basis of selection of a specific gage control system.

Sources of Off Gage

There are three main sources of off gage in a hot strip mill. First, the temperature run-down from the head to the tail end of the slab causes a gradual increase in gage from the head to the tail end of the strip. Second, the water-cooled skids in the reheat furnace produce cold spots in the slab which result in additional gage variations as these cold spots pass through the strip mill. The third source of gage variation is the loss of tension at the tail end of the strip, which commences as the tail leaves the early stands.

The correction of gage variation caused by temperature run-down usually determines the range that is required in the automatic gage system. In general, the longer the slab, the greater the temperature run-down. As slab length increases, more range is required in screwdown control, and there will be more load build-up in the stand drive motors. For these reasons, it is concluded that longer slabs require more regulated stands in order to reduce the range required in any particular stand.

The most abrupt gage change ordinarily encountered is that due to the cold spots which result from the water-cooled skids in the reheat furnace. These skid marks usually determine the speed of response required in a gage control system. If the system is fast enough to significantly reduce the variations resulting from cold spots, the system will also be fast enough to regulate the variations from other sources.

Loopers Improve Tail End Gage

The off gage at the tail end of a strip due to the loss of tension (Fig. 1) is also a rather abrupt change and may impose severe duty on the automatic gage control system if no other steps are taken to reduce this effect. To attack this problem the hot strip mill should be operated with low tension between stands so that this loss of tension produces less tail end gage build-up. To insure operating with low and more constant interstand tension, loopers should be up when strip is between stands. The tail end effect will be reduced and there will also be less width variation.

Such operation is a major change in practice for most mills. Only a few mills are operating today with loopers up, but there is a clear trend in this direction because of the superior quality resulting.

Automatic loopers make it feasible to operate with loopers up to obtain the better quality resulting from lower, more constant interstand tension. Today, improved design loopers are automatically raised and lowered. Looper position regulators electrically detect the looper height, and automatically vary the stand motor speed to hold the loopers at the proper position. The operator is relieved of the burden of raising and lowering loopers and trimming the motor speeds.

Which Stands Should Be Controlled?

The temperature run-down and skid mark effects result in hardness variations causing variations in mill spring and thus in thickness.

The hardness variations progressing through a multi-stand mill cause a phenomenon we call "grow-back." For example, if stand 2 screws are operated to cause stand 2 to produce constant gage, stand 3 still produces gage variations. Even though stand 3 receives constant gage, it does not receive constant hardness. Thus, the gage variations removed in stand 2 partially grow-back in stand 3 and remaining stands.

To minimize grow-back one is encouraged to control the screws as late as possible in the mill. A consideration of grow-back alone infers that we should control screws and gage in stand 6, since there is no grow-back after stand 6. However, this is not possible because stand 6 is the shaping stand; it takes a light reduction and can have only a small range for gage control.

The next stand to consider is stand 5. This location is near the delivery point of the mill, and the reduction is sufficient to provide range for gage control. However,

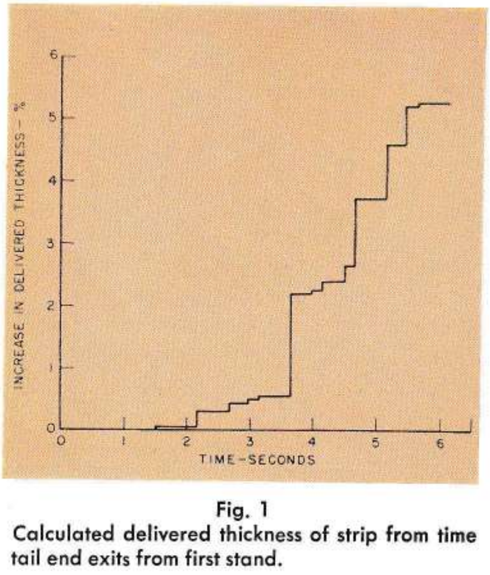


Fig. 1
Calculated delivered thickness of strip from time tail end exits from first stand.

even stand 5 does not have sufficient range for gage control if the hardness variations are significant. For an average strip of 60 seconds length, the temperature run-down and skid marks produce sufficient hardness variations that automatic gage control on stand 5 only would produce objectionable load changes on the stand 5 drive motor, and might cause a shape problem from stand 5.

Therefore, for a 60-second strip one should consider gage control on stands 4 and 5 at least (Fig. 2). In some cases where temperature variations are severe or mill stiffness is low, more stands of gage control should be used. One mill equipped with gage control sometimes runs slabs over two minutes in length and employs gage controls on stands 2, 3, 4 and 5. In this way, load swings are shared over the several stands.

Sensing the Gage Variations

Gage variations may be measured by interstand X-ray gages or by load cells.

The load cells measure roll force and thus the mill spring. As the strip hardness increases, the roll force increases and the rolls spring apart. This change is detected by the load cells and simple electric circuits. The gagemeter method of detecting thickness variations provides an instantaneous signal of thickness change. The principle and detailed system have been described in previous papers.*

The interstand X-ray gages are difficult to install and are subject to damage by cobbles. Also, there is a time delay as the strip passes from the roll bite to the gage so that the control is not as fast in response as one which uses a load cell sensor.

It is not very satisfactory to use the X-ray gage after stand 6 to control clear back to stands 4 and 5, because the transport lag is so long that control response becomes very slow. Since coil ends are such a significant percent of coil length, much of the benefit of gage control would be lost.

Load cells are the accepted way of detecting gage variations in intermediate stands. Five hot mill gage controls are in operation using load cells and more are being installed. Load cells have vastly improved mill set-up and operation. Levelling and set up after roll change almost become a science. With load cells it is not necessary to run a test bar after each roll change.

X-Ray Monitor

Thus far the discussion has been limited to the use of the intermediate stand screwdowns. Such control will reduce gage variations but will not necessarily produce perfect final gage for several reasons. First, the gagemeter drifts due to roll wear and heating. Second, there is some grow-back in stand 6. And finally, the operator set-up may not be perfect. For these reasons a monitoring signal from the stand 6 X-ray gage is fed back into the gagemeter stands to recalibrate them to correct for slow drifts and mill set up errors so as to produce correct finished gage.

Vernier Gage

While stand 6 only has a small range for gage control, it can be and is used to obtain a fast response correction for the small grow-back in stand 6 itself. Stand 6 speed is varied over a small range causing a small variation in interstand tension to achieve the vernier gage correction. The stand 6 X-ray gage is used as the sensor. Since the transport time from stand 6 to the X-ray gage is short, this sub-system can have fast response and correct small errors before the overall monitor system operates.

Experience with AGC

Before and after comparisons from actual mills have been made. Oscillographic strip charts illustrate before and after transient performance for large slabs, small slabs, thin strip and heavy strip. Gage deviation data has been collected automatically in numerical form, analyzed on a large scale digital computer, and then plotted into distribution curves of gage deviation for comparisons. As of April 15, 1961, numerical data on over 18,000 coils and 19,000,000 feet of strip on two hot strip mills have been statistically analyzed.

Performance of a mill prior to gage control is shown in Fig. 3. Coil rolling time is approximately 80 seconds. These coils were direct rolled without slab reheating so cold spots do not exist. Gage variation is significant—about 8 mils.

Performance with automatic gage control is shown in Fig. 4. Gage variations are reduced to approximately ± .001″ from average thickness except at extreme ends.

Performance of another finishing mill is shown in Figs. 6 and 7. Bars were rolled with, and then without, automatic gage control. Without gage control the normal thickness variation for both heavy and light gage is about the same 8 mils obtained at the other two plants. With gage control rolling heavy gage the variation is only 3 mils, even including the last 25 feet. Excluding the part after the tail leaves finishing stand 5, the variation is only 2 mils. On light gage the variation over the whole coil is only 2 mils.

As mentioned, data has been logged in numerical form, analyzed and plotted to obtain accurate representation of long-term performance. Before and after performance on one mill is shown in Fig. 5.

The very uniform gage also permits rebalancing and better utilization of overall plant rolling mills. For example, most hot rolled strip is further reduced in thickness in cold reduction mills. Productive capacity on this hot strip mill has been increased 2 percent by rolling on the plus side of nominal. Even though the average thickness into the cold reduction mills may be 2 percent heavier, the much more uniform incoming gage contributes to a gain in productivity on the cold mill as well as on the hot mill.

Strip beyond commercial tolerance (assumed ± 10 mils) has been cut from 4 percent to zero. Thus, there has been an improvement in yield of 4 percent which, added to the capacity increase of 2 percent, gives a total initial benefit from automatic gage control of 6 percent.

A very interesting comparison is the continuing improvement being achieved as the operators become more familiar with the system. Performance in April without gage control and September and December with gage control is shown. The improvement between September and December should be noted. Minor mill set up adjustments during or after the first coil could effect further substantial improvement.

Similar gage performance data is also available from another hot strip mill (Fig. 6). This mill rolls similar products for the same market but averages about 20 items per order rather than five.

Because of the more items per order, performance is somewhat better than for the preceding mill, even though coils on this mill are significantly shorter (Fig. 7). Here there has been a 36 percent improvement between ± 2 mils and a 3.3 to 1 reduction beyond ± 4 mils. Actually, gage performance of the two mills is now quite similar.

The proved statistical accuracy of this automatic gage system permits a steel company to impose tighter tolerance requirements upon rollers. Products can be rolled on the basis of more square feet per ton, or more tons per square foot, or for

---

* Methods of Control of Strip Dimensions on Hot Strip Finishing Mills, R. A. Phillips, Iron & Steel Engineer, May 1958.

* Systems Analysis & Design for Hot Strip Mill with Automatic Gage Control, H. S. Maxwell and R. A. Phillips, Iron & Steel Engineer, April 1960.

* Integrated Automation for Steel Plants, W. M. Krummel, Iron & Steel Engineer, October, 1961.

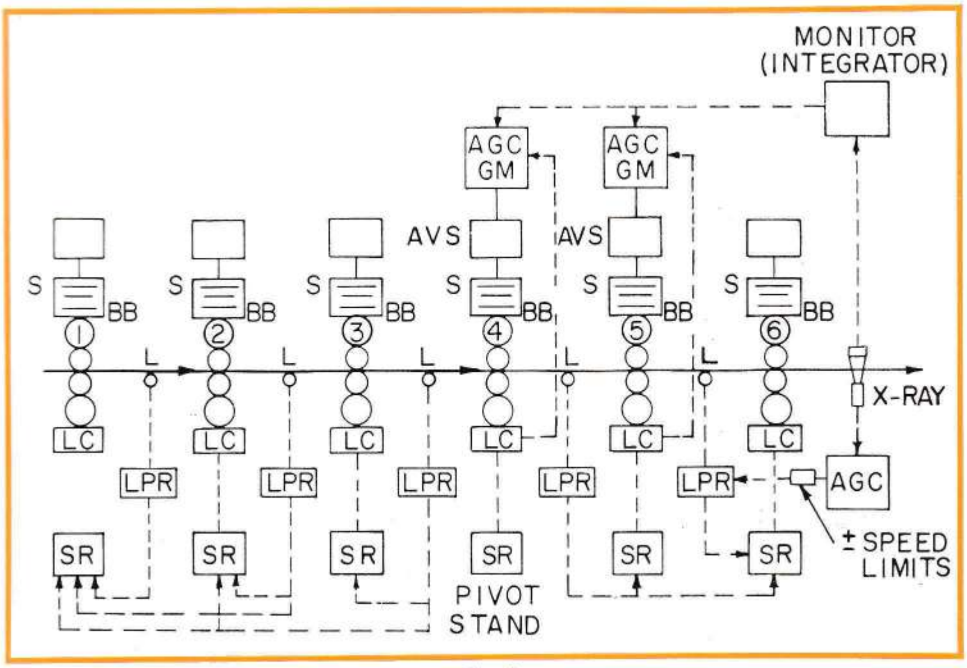


Fig. 2
Hot strip mill automatic gage control system should include a minimum of two gagemeter screwdown systems. For long slabs four such systems should be used.

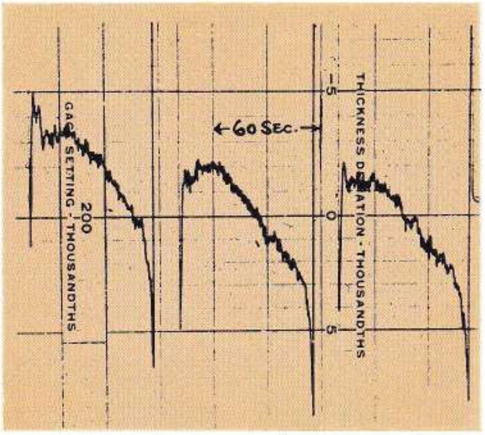


Fig. 3
Gage performance of hot strip finishing mill equipped with speed regulators (zero droop) rolling coils of approximately 80 seconds duration. (Conventional strip chart recorder over-emphasizes ends.)

what the market or facility balance requires. Automatic gage logging systems permit immediate accurate readout of performance. Incentives are easily and accurately related to quality and tonnage. Rolling practice is improved. Costs are reduced.

The Basic Gage Control System—Summary

The basic gage control system (Fig. 2) monitors thickness out of several stands and operates through screwdown drives. Mill speed adjustments are made to hold uniform and low interstand tension to assure constant width. A vernier system monitors finish thickness and does momentarily vary tension, but only between stands 5-6, where width is not easily affected.

Long slabs will require more stands of screwdown control than short slabs. If the time spacing between slabs is extremely short (two seconds), then possibly the number of screwdown stands might have to be greater than indicated only by slab length.

Main drive motor rolling loads and the increase due to gage control must be considered in selecting the gage control system. Charts obtained from a digital computer analysis are available for this purpose. Parameters such as slab temperature variation, mill modulus and stands having gage control are considered. From this study it is possible to determine the distribution of increased main drive motor load necessary to accomplish gage control.

The very significant improvements in performance lead one to anticipate that automatic gage control will be applied to every important hot strip finishing mill throughout the world within the next several years.

Computer Control

The next step, computer control, has already been taken by several steel companies. One current performance limitation, operator evaluation time after an

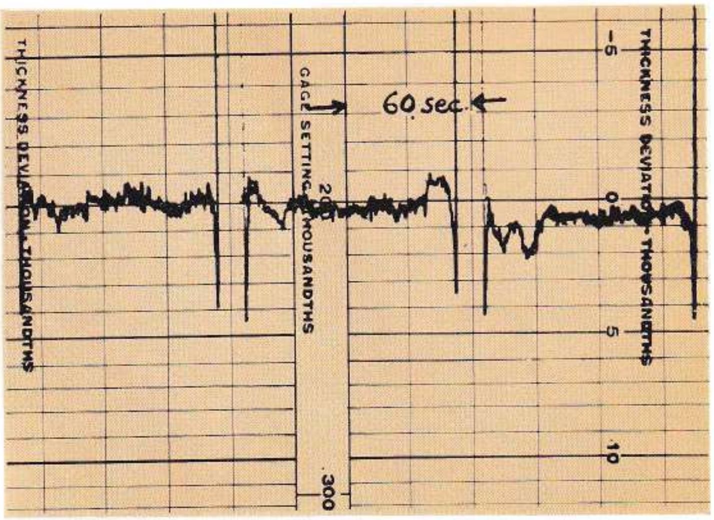


Fig. 4
Gage performance of hot strip finishing mill of Fig. 3 with automatic gage control in operation. Coil rolling time about 90 seconds, finish gage .063" x 36". (Conventional strip chart recorder over-emphasizes ends.)

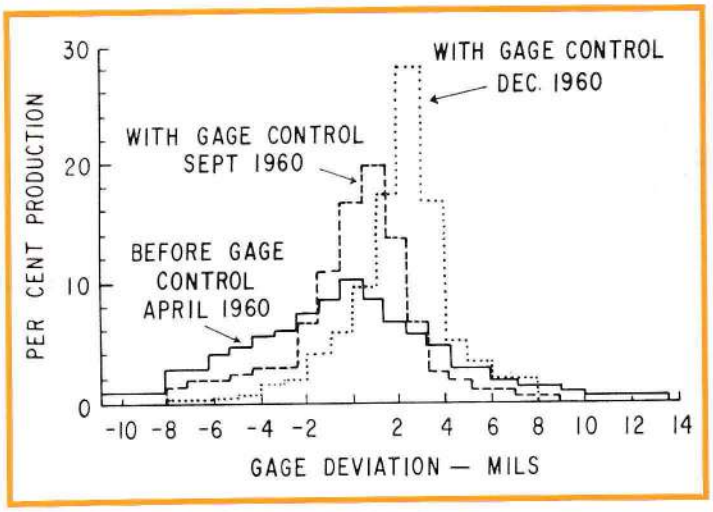


Fig. 5
Distribution of gage deviation on finishing mill. Strip beyond commercial tolerance (± 10 mils) has been cut from 4% to zero even with system set up to roll 2 mils above nominal gage.

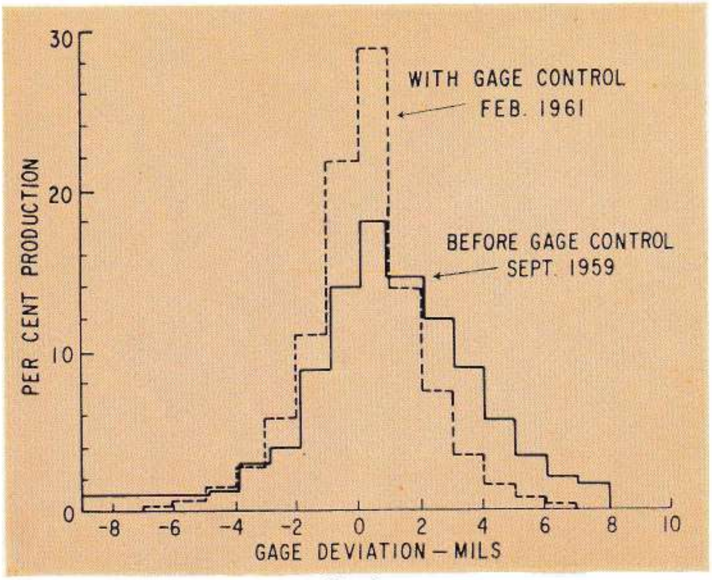


Fig. 6

Distribution of gage deviation on another finishing mill. This mill averages significantly more coils per order than preceding mill.

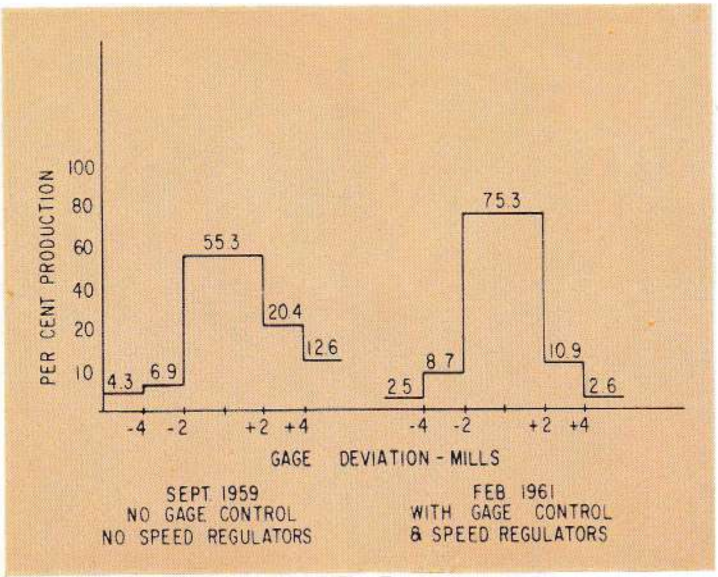


Fig. 7

Distribution of gage deviation on this hot strip mill shows 36% improvement between ± 2 mils and a 3.3 to 1 reduction beyond ± 4 mils.

order change, will be significantly shortened.

With the computer control system now being installed, the basic inputs are grade of steel and desired delivery speed and gage. Automatic inputs are incoming slab thickness, width, and temperature.

The computer makes the required calculations in accordance with a stored program to derive the optimum speed, screw setting and roll separating force for each stand. A simple operator's adjustment will modify the computer program to limit the load on any stand(s) to protect the mill. This function can also be used when necessary to "dummy" a stand. Another operator's adjustment allows for operation of the last stand at a constant draft, a common operating practice, to properly control shape. The computed roll separating force, speed and screw position settings are then used as the references to the gage control, main drive and auxiliary drive regulating loops.

The computer control performs numerous other functions compatible with an automated system (Fig. 8). It may take care of the complete strip mill from the reheat furnaces to the coil conveyors. Slabs can be automatically tracked from the time they are loaded into furnaces until they emerge as completed coils on the delivery conveyor.

Automatic bar temperature control is provided from the furnace through to the coilers. If a bar is too cold, the computer can specify the possible minimum thickness to the finisher. Sprays may be automatically controlled for correct coiling temperature. Sideguards are automatically positioned. X-ray and width gages are automatically set.

The computer system performs data logging for production control and accounting functions. Data such as coil identification, footage total, footage off-gage and footage off-width are accumulated and typed out on a pre-printed format. Calculated tonnage and down time are assembled and typed out upon demand.

Instructions may arrive and data be sent electronically from an area system, or paper tape, card and typewriter input and output may be used.

With computer control further improvements in yield and reductions in operating cost are anticipated through improved mill set up, reduction in cobbles and reduced mechanical maintenance. With three hot strip mills currently planned for computer control, it is anticipated that additional installations will be contracted during the coming year.

The Integrated Automation System

"Integrated automation" has been defined as step-by-step automation of separate processes, each as self sufficient as possible, and integrated into an overall automation system based on the needs of the business, whether large or small. In order to convey the idea of automating in steps, first one process, then another, the steps are referred to as "islands of automation." The computer-controlled hot strip mill island has already been discussed.

The material and information flow diagram for the hot strip mill island is shown in Fig. 8. The process computer performs two basic functions—operating control and order and data control. Order information is obtained from an area system and output data flows back to the area system.

Islands of automation such as the hot mill processes may be combined into an area automation system such as shown in Fig. 9. Such systems are being considered by several steel companies. It is anticipated that similar real time combination production scheduling and process control systems may be contracted for during the coming year.

As we tie several automated areas together we achieve the fully automated steel plant. With such a system this area computer would communicate with other area computers and with the central computer.

Integrated automation represents the combination of some or all the functions of operations, engineering, production planning, accounting and marketing in the interests of economy, efficiency and relative simplicity.

Ultimate Automation: Proposed Methods of Attainment

The concept of ultimate mill automation extends well beyond the scope of equipment and system design that the industry could be expected to purchase immediately. However, the interests of the steel plant are served best by studying the plant in terms of ultimate total automation insofar as possible, and then by proposing a logical step-by-step approach to attaining the ultimate.

Each step proposed must itself be capable of producing real benefits, and must continue to produce these benefits after the implementation of subsequent steps.

Each step likewise should consist of small-to-moderate size building blocks.

Ultimate automation of a typical mill area would include all or some of the following automated functions:

- Completely automatic operation of all rolling and processing units, including set-up adjustments, threading or starting, running, shut-down, and emergency corrective actions.
- Completely automatic product flow through the area.
- Ordering and expediting of finished and semi-finished products, raw materials, supplies, and spare parts.
- Packing, labeling, warehousing, and shipping of finished products.
- Maintenance of inventory levels of raw materials, steel in process, finished products.
- Order service activities and communications with sales offices.
- Production-planning, including forecasting of labor and processing unit utilization, and planning of maintenance schedules.
- Payroll, cost, and general accounting.
- Production, financial, customer service, maintenance, and general management reporting.

In order to be realistic and economically justifiable, integrated automation for a particular steel plant must be based on the business and operating "facts of life" facing the individual steel plant and steel company.

The Present and the Future

The automated hot strip mill is now improving operating cost and product quality.

Automatic gage control is proved. Steel users know strip is being produced with closer tolerances. They can measure their savings in die life and assembly costs.

Computer control is designed and being placed in operation. Interest is widespread. Potential savings are significant.

The systems know-how, equipment and manpower to attain integrated automation are available now. The incentive for the steel company is there, in terms of both immediate profit and protection of future business position.

Hot strip mill automation is profitable. Payoff periods are short. While each case needs to be studied individually, one to three years is common. Operations research and synthesis techniques can be used to determine the systems best suited to particular situations and to estimate the value of the benefits expected.

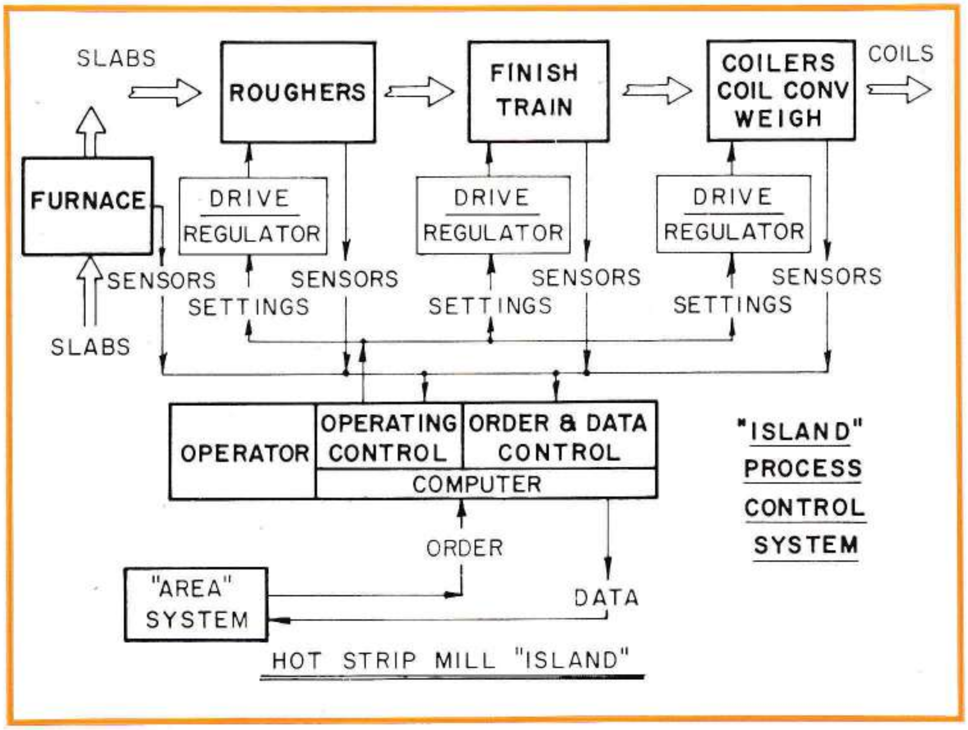


Fig. 8

Process automation should proceed on a planned basis. Of all the islands the hot strip mill promises the most significant return on investment.

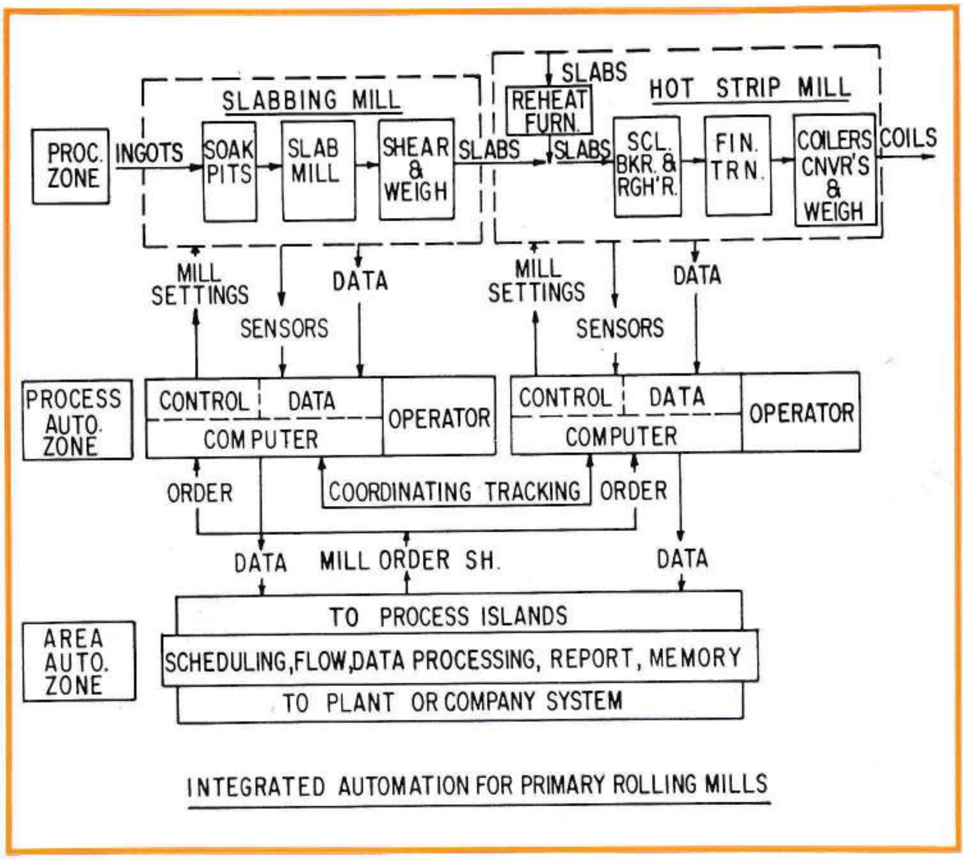
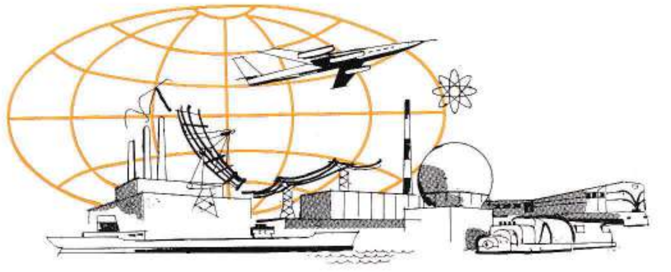


Fig. 9

Automation islands may be logically combined into automation areas. Process control may be combined into an integrated automation system.

IGE ACROSS THE WORLD



Systems Students

One of the U. S. electrical industry's most widely recognized study programs is the eight-month Power Systems Engineering Course conducted by General Electric at Schenectady, N. Y. It provides intensive instruction in power engineering and is designed specifically for electric utility engineers.

The course also serves as a medium for the exchange of ideas among the participants, and provides the nucleus of personnel needed to develop technical training programs within the participating utility companies.

This year five engineers from overseas electric utility companies are participating in the 30-week course, the largest number of overseas participants ever to be enrolled at one time since the course was instituted in 1949. They are:

Migual Barandiaran, Iberduero, S. A., Spain; Jesus Gamiz Sada, Comision Federal de Electricidad (CFE), Mexico; Achille Taschini, Edisonvolta, S.p.A. (Edison Company), Italy; Mitsuhiko Uchiyama, Tokyo Electric Power Co., Inc., Japan; and Yasuyuki Ueda, Kyushu Electric Power Co., Inc., Japan.

POWER GENERATION

Record for Argentina

An Argentine electric utility has awarded a $12.3-million contract to IGE for the largest steam turbine-generator installation in Latin America.

The contract awarded by Servicios Electricos del Gran Buenos Aires, S. A. (SEGBA) for its Puerto Nuevo steam power plant, currently the largest in Argentina, includes a 194,000-kilowatt steam turbine-generator and associated electrical and mechanical equipment. When this unit, largest ever ordered south of the United States, is placed in operation, Puerto Nuevo, will have a generating capacity of 649,000 kw, making it the largest in Central and South America.

The new installation is the eighth in Puerto Nuevo, which supplies electric power to the greater Buenos Aires area.

As prime equipment contractor, IGE will furnish the turbine-generator, switchgear, transformers, motors, motor controls, and station control boards. IGE will subcontract for the boiler, condenser, feedwater heaters, pumps, piping, valving, air compressors and combustion controls.

To finance the expansion project, SEGBA has been granted a $13,200,000 loan by the Export-Import Bank of Washington, in which IGE is participating.

The steam turbine-generator will be built in General Electric's Schenectady, N. Y. plant, and is scheduled to be placed in operation at Puerto Nuevo on June 30, 1963. Other electrical equipment for this installation will be manufactured in General Electric plants in Philadelphia; Pittsfield, Mass.; Roma, Ga.; Salem, Va.; Lynn, Mass.; Bloomington, Ill.; Plainville, Conn.; San Jose, Calif. and Chamblee, Ga.

Power in a Hurry

Argentina's government-owned electric utility has placed a $6-million order with International General Electric for five gas turbine-generator package power plants to meet emergency power needs in Buenos Aires.

Agua y Energia Electrica, a government agency that supplies electricity to various sections of Argentina not served by private utilities, will use the new units primarily to ease a power shortage in the greater Buenos Aires area. Three of the five new units, which will be manufactured by General Electric's Gas Turbine Department in Schenectady, N. Y., will be installed at the Tablada power station and two at the Moron station, both near Buenos Aires.

Clifford F. Storms, manager of electric utility sales for IGE, said the package power plants were selected by the utility because they could be put into operation in a relatively shorter time than other generating facilities, and because they could be readily moved to other locations where power shortages may exist.

Designed to burn either gas or distillate oil fuel, the units are rated 10,500 kilowatts continuous and 11,250 peak at 80 degrees F. at 1,000 ft. elevation. Storms pointed out that the dual-fuel capability of these plants allows the utility to take advantage of the lower-cost fuel. He added that operating costs are further reduced by the remote control system, which permits running the plant as an unattended station.

The IGE order includes associated mechanical and electrical equipment, design engineering and supervision of erection and testing. General Electric Argentina S. A., a subsidiary of General Electric, will install the units.

Bulky Shipment

Included in a sizeable order for electrical equipment placed with IGE by Argentina's national railways system a year ago were two giant 60,000-kva, three-phase 50-cycle transformers. This fall they were shipped to Buenos Aires and were unloaded on the dock by a huge harbor crane.

But transporting the big units to the site at Martinez, 15 miles away, was another matter. The transformers not only weighed 120 tons each, but had bulky dimensions that posed a problem. The job called for careful advance planning on the part of General Electric Argentina, S.A., which arranged for a special flat-bed truck and mapped a highway route that carefully skirted low railway bridges and other possible obstructions.

The contract between IGE and Empresa de Ferrocariles del Estado Argentino (EFEA) called for electrical equipment additions to two existing substations and equipping a new substation in the subur-

BIG SHIPMENT: Giant 60,000-kva transformer swings onto dock at Buenos Aires.

ban district of Martinez to provide power for the Mitre Railway in Buenos Aires.

The two Martinez transformers will transform high voltage down to 13.8 kv and 21 kv for use, respectively, in the distribution lines of the local power company —Agua y Energia Electrica—and Mitre Railway substations.

General Electric Argentina, S.A. has received a contract to install the substation equipment.

INDUSTRIAL GROWTH

Data at Kudamatsu

Toyo Kohan Co., Ltd., a leading Japanese tinplate producer, has purchased an automatic data inspection accumulator from International General Electric for a 38-inch electrolytic tinning line at the Kudamatsu plant.

The General Electric 302 data inspection accumulator system will work in conjunction with the normally used line sensors and will provide for manually inserted coil data in addition to other tabulations. A permanent record of the quality and length of each coil with complete coil identification in typewritten form will be immediately available to the operator.

According to IGE engineers, use of the General Electric magnetic-drum data storage system and solid state devices assures steel plants of the high degree of reliability, ease of maintenance and flexibility demanded by the industry.

New Stainless Line

International General Electric has been awarded an order for a continuous stainless steel bright annealing line for the Nippon Kinzoku Company, Ltd., of Tokyo.

IGE will be prime supplier of the equipment package, the third continuous bright annealing line ordered by Japanese steel companies since the development of the high-production bright anneal furnace was announced last year, by GE's Industrial Heating Dept., Shelbyville, Ind. The Nippon Kinzoku order is the fourth of its kind in the steel industry outside the U. S., all for General Electric equipment.

The contract includes the furnace, atmosphere equipment, electrical drives and control, terminal equipment and engineering drawings. The vertical tower furnace is rated to bright anneal type 430 stainless steel strip 24 inches wide and .008 to .080 inches thick at a rate of 6,000 pounds per hour. Other types of stainless steel having widths between 12 and 27 inches can be annealed in the furnace.

ATOMIC ENERGY

Improved Containment

An improved method of reactor containment for nuclear power plants is described as affording a number of potential safety advantages over current containment systems. The advanced system, called pressure suppression containment, is reported to be most suited for compact nuclear systems. For such systems, it is said to be simpler and less expensive than the conventional containment sphere or capsule which has become the symbol of atomic stations.

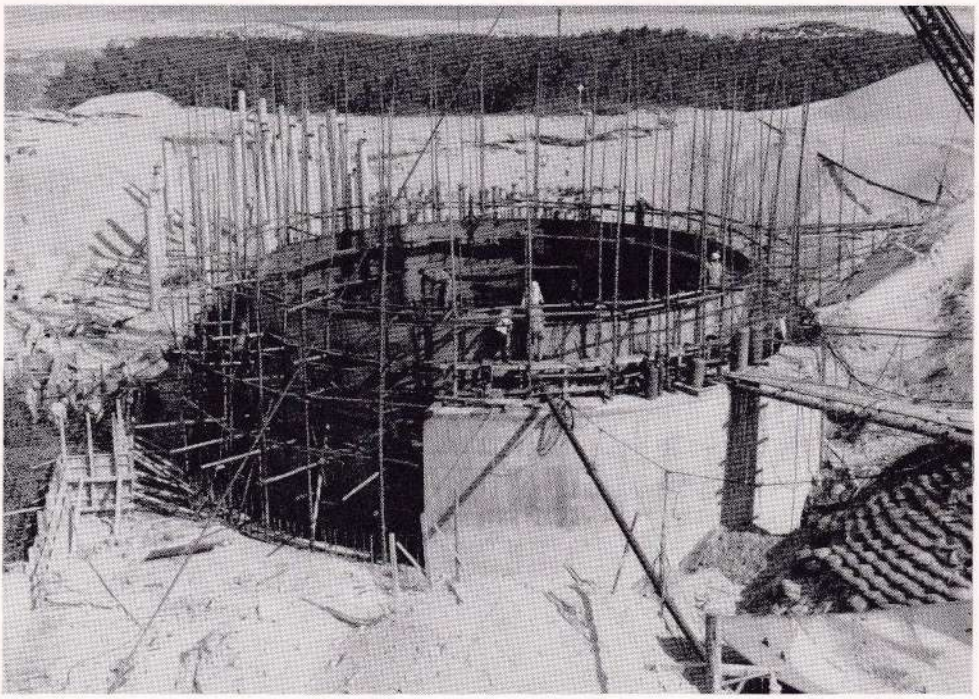
Developed by Pacific Gas & Electric Company and General Electric Company, USA, pressure suppression containment will initially be used at PG&E's 50,000-kilowatt Humboldt Bay nuclear unit, now under construction at Eureka, Calif.

Pressure suppression is also planned for the 325,000-kilowatt nuclear power plant PG&E intends to build at Bodega Bay, about 50 miles north of San Francisco.

Engineers of the two companies told the American Society of Mechanical Engineers that tests conducted on the system show it has "large margins of safety" for protection of operating personnel and the public against the hazards resulting from an accidental failure in the nuclear system.

They pointed out, however, that the probability of a serious failure occurring in a nuclear system is extremely remote because of the careful engineering and construction incorporated in atomic-electric plants.

In the pressure suppression containment system, the reactor vessel is enclosed in a "dry well" which is connected to a water pool by a series of pipes.



PROGRESS IN JAPAN: Japan's first boiling water reactor power plant is taking shape 60 miles northeast of Tokyo. The 12,500-kilowatt unit is expected to produce the first atomic-electric power in the Far East when it begins operation late this year.

If a rupture should occur in the pressure vessel system and its associated equipment, heat from the escaping steam and water would be absorbed in the water pool, which also serves as a retention basin for radioactive fission products that might be released.

Co-authors of the paper were D. B. Barton and C. P. Ashworth of PG&E and C. H. Robbins and Earl Janssen of General Electric's Atomic Power Equipment Department, San Jose, Calif.

Full Power at Kahl

Kahl Nuclear Power Station, West Germany's first atomic power plant, began initial full power operation late in November. This milestone represents the completion of criticality and intermediate power testing for the General Electric-built reactor.

The 15,000-electrical-kilowatt plant is located at Kahl, near Frankfurt, and is owned by two large German utilities, Rheinish Westfaelisches Elektrizitatswerk and Bayernwerk (AG). Prime contractor for the plant was Allgemeine Elektricitats Gesellschaft of Frankfurt.

Full-power operation began after receipt of authorization from the Bavarian ministry for test operation at the rated power of 58,000-thermal-kilowatts. During the past four months the plant has been test-operated at power levels up to 75 per cent of rated power.

The station produced Europe's first privately financed atomic-electric power June 17, 1961.

The Kahl plant is considered to be a forerunner of large nuclear power plants now being considered by West German electric utilities. It also provides facilities for training of personnel for large stations and for nuclear development.

The reactor installed at the station is a natural circulation, indirect-cycle boiling water reactor designed and fabricated by General Electric at San Jose, Calif. It was supplied through International General Electric Operations S. A.

The Kahl plant is the first of three overseas nuclear power projects with General Electric reactors to begin operation. Both the others—the 150,000-electrical kilowatt SENN plant in Italy, and the 12,500-electrical kilowatt plants for JAERI in Japan—are scheduled to go into operation in 1963.

New Test Facility

A $100,000 facility for testing reactor control rod drives has been placed in operation at General Electric's Atomic Power Equipment Department (APED) in San Jose, Calif. General Manager George White said the new facility was built to supplement existing facilities for quality control testing of more than 200 control rod drives which General Electric is now manufacturing.

The drives, part of the control and safety system of a nuclear plant, are for use in reactors which APED is building for the Societa Elettronucleare Nazionale (SENN) on the Garigliano River near Naples, Italy; the Japan Atomic Energy Research Institute (JAERI) at Tokai-Mura, and several U. S. nuclear power installations.

Major feature of the new facility is a combination of three pressure vessels—a 10-inch diameter and an 8-inch diameter vessel for testing locking piston-type drives, and a 3-inch diameter vessel for testing twin-screw drives—which will permit simultaneous testing of various drive designs.

Other equipment includes control and instrumentation consoles to measure performance under pressure and flow, and a hydraulic control and scram system.

Operating tests of drives are made under cold, pressurized conditions, as well as at elevated temperatures and pressures to simulate actual design conditions.

Control rod drives are used to start, stop, and adjust the rate of fissioning of the uranium fuel by inserting or withdrawing a control rod blade through the reactor core. The drives thus control the power output of the reactor.

TRANSPORTATION

Fuel Cell for Rails?

Use of the fuel cell as a source of power for railway locomotives is seen as a possibility for the future by Robert M. Coultas, manager of locomotive sales for the Locomotive & Car Equipment Dept. of General Electric.

Coultas discussed the fuel cell, or fuel battery, along with other sophisticated locomotive-power sources in an address at a two-day seminar in Chicago sponsored jointly by the Association of American Railroads and the Armour Research Foundation.

In terming the fuel battery as potentially applicable to locomotives, Coultas said:

"The fuel batteries which are furthest advanced today use hydrogen as the fuel ... A tremendous incentive exists to use hydrocarbon fuels directly in the fuel battery, since only with such a fuel can the full potential to generate electrical energy at low cost be realized."

Other potential motive-power systems discussed by Coultas included the gas producer-gas turbine cycle, such as is now in locomotive operation on the Swedish State Railways; the diesel-hydraulic; the nuclear-powered electric concept for locomotive application.

Coultas said the fuel battery, as a direct source of d-c current, offered the possibility of series hookups to produce high voltages, and could result in "a very attractive means of railroading from the standpoint of both reliability and efficiency, since a minimum of energy conversions is involved."

AVIATION

VTOL Engine Tested

Flight testing of General Electric's T64 turboprop was started last fall in Downsview, Ontario, Canada, with two of the 2,850-horsepower gas turbines powering a de Havilland DHC-4 Caribou flying test bed. The Caribou operated between four and 12 thousand feet at the de Havilland plant.

In-flight testing of the Caribou with T64-4 engines is scheduled for completion early this year, according to E. Woll, general manager for General Electric's Small Aircraft Engine Department.

Woll emphasized that the Caribou was being used only as a test vehicle, but added that a Caribou developed with turbine engines would have doubled its payload, improved take-off and climb performance, increased speed and service ceiling while maintaining the aircraft's operating economy.

The current flight test program is being conducted by General Electric and de Havilland under sponsorship of the U. S. Navy, for whom the engine is being developed, and with the cooperation of the Canadian Department of Defense Production and the Royal Canadian Air Force.

The T64 is under consideration for a number of civil and military applications, and has been selected as powerplant for the United States tri-service VTOL transport to be built by Ling-Temco-Vought, Ryan Aeronautical Company and Hiller Aircraft Corporation.

FLYING TEST BED: T64 turboprop engine is tested in de Havilland Caribou over Ontario farmland.

Designed for a variety of applications including VTOL/STOL, helicopter and conventional aircraft, the T64 is the first American gas turbine with fuel consumption approaching that of reciprocating engines. It can be operated continuously at angles from 100 degrees nose up to 45 degrees nose down and has a building-block design. Two turboprop and one turboshaft configurations are derived by addition of gearing.

Development of the T64 began in 1957 and up to the start of the current flight test program the engine had accumulated more than 8,000 test hours.

The conventional piston-powered Caribou, a short take-off and landing (STOL) troop and cargo transport capable of operating from rugged battlefront areas, is currently in service with the U. S. Army, RCAF, and other Free World forces, plus the United Nations.

VISITOR TO U. S.: Ramon Cabezon, right, of International Machinery Co., Chile, inspects GE's new 2500-horsepower diesel-electric locomotive on recent visit to General Electric plant in Erie, Pa. With him is R. A. Williamson, manager of export locomotive sales.

NUCLEAR FUEL CHECK: A General Electric technician checks dimensional tolerances on one of the nuclear fuel elements for Pacific Gas & Electric's Humboldt Bay atomic power unit. The $20-million plant is near Eureka, Calif. Each of the 172 fuel elements will undergo rigorous tests.

NEW DEVELOPMENTS

Instrument Life Doubled

Two new tachometer-generators, capable of operating more than 2,000 hours on jet aircraft, have been developed by General Electric's Instrument Department, West Lynn, Mass. The new instruments more than double the previous design operation life of 1,000 hours.

The new tachometer-generators, models 2CM9ABH-7 and 2CM9-ABK-7, were designed to increase reliability, reduce maintenance costs and reduce premature removal of these components on jet engines. The 2CM9ABK-7 and 2CM9ABH-7 have two and three pin receptacles respectively.

The design applications of both models have been proven by laboratory and flight test evaluations. Significant feature of the instruments is an improved bearing system, including new bearing mounting, new lubrication and an increased raceway curvature radius. Stainless steel bearing material eliminates corrosion problems and grain growth at elevated temperatures. The usual oil seal is eliminated since leakage will not cause generator failure in either model.

The generators will operate from sea level to 70,000 feet, in ambient temperatures from −85 to 350 degrees Fahrenheit.

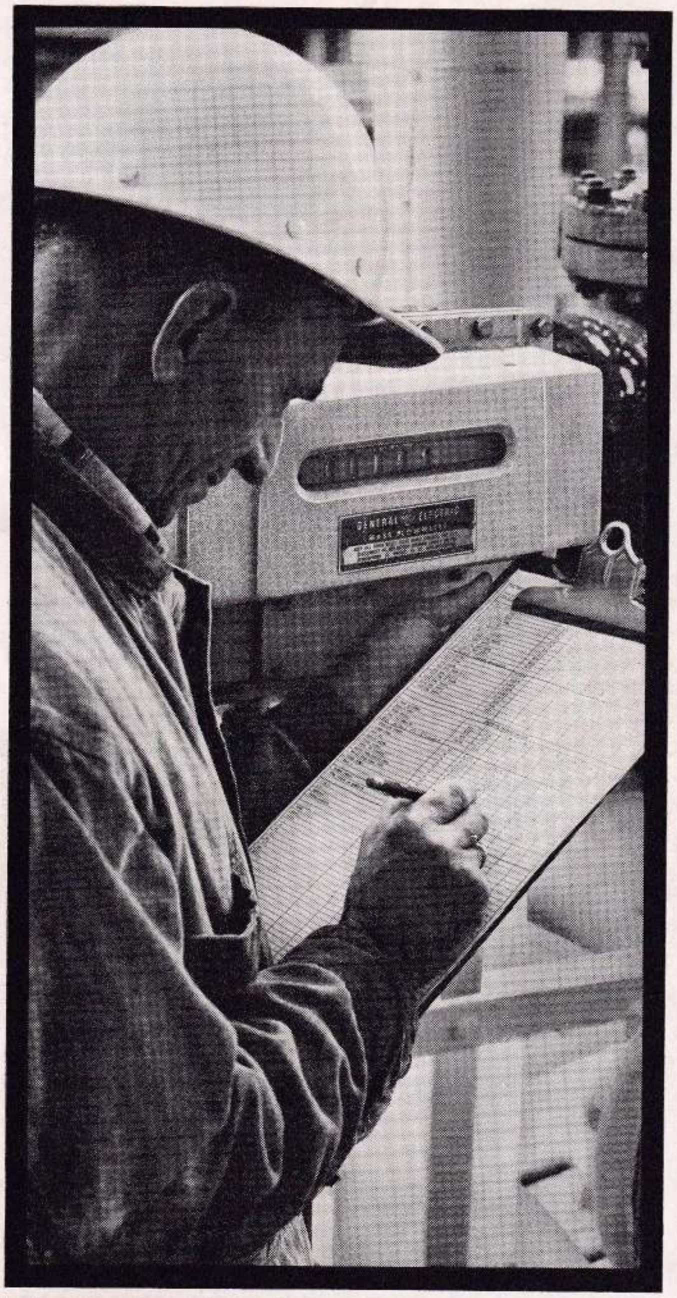
A World's First

The world's first high-current circuit recloser to interrupt power arcs in vacuum has been developed by the General Electric Co. in its Philadelphia plant.

With a rated interrupting capacity of 8,000 amperes at 15.5 kilovolts and 12,000 amperes at 4.8 kv, the new vacuum recloser marks the first step toward providing utilities with a complete line of oil-less high-speed circuit breakers.

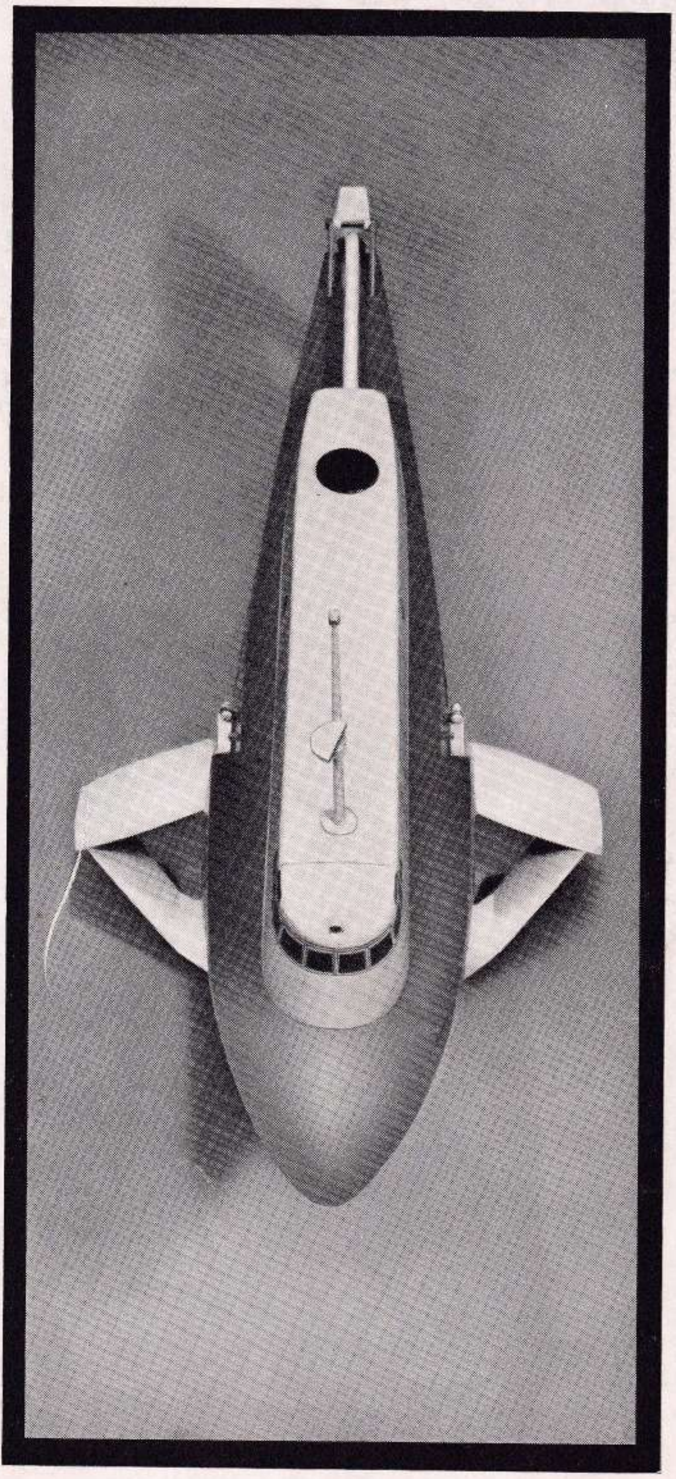
The recloser's instantaneous clearing time is less than two cycles, including fault sensing, tripping and circuit interruption. It is believed to be the fastest heavy-duty circuit recloser available today.

General Electric serves industry and progress



Performance-Proved. The G-E mass flowmeter is the answer to many fluid flow measurements for industry. General Electric's mass flowmeter provides faster and more accurate measure of fluids directly in pounds or kilograms. This measurement is not affected by wide variations in pressure, temperature, density, and viscosity. Since the flowmeter registers a direct reading in weight, all types of compensating elements and costly hand and machine computations with their resulting errors are eliminated. For further information on the mass flowmeter, write for bulletin GEA-6925B. *International General Electric Co., Dept. 032-17X, 159 Madison Ave., New York 16, N.Y., U.S.A.*

A "Flying" Boat. This experimental hydrofoil craft being built for the U.S. Maritime Administration is powered by two General Electric turboshaft engines. The primary power plant is the Model 240 turboshaft engine, which will power the MARAD hydrofoil in the "flying" position at speeds up to 60 knots. This newly designed marine engine weighs only one-tenth as much as an equally powerful diesel power plant and can run on a variety of fuels. The other engine is the Model 720, which powers two water jets to provide maneuverability when the foils have been retracted for operation in shallow water. The 104-foot craft is being built by Dynamic Developments, Inc., subsidiary of Grumman Aircraft.



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